MEASUREMENTS AND OBSERVATIONS OF INTERFACIAL CREEP IN ENGINEERING SYSTEMS

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In many applications, large shear stresses develop at interfaces between dissimilar materials during thermo-mechanical excursions, when there is a significant difference in the coefficient of thermal expansion between them. When the system is elevated to a high homologous temperature for one of the adjoining materials, the applied shear stress may allow the interface to slide without debonding by a diffusionally accommodated mechanism, thereby allowing relative dimensional changes to occur. The purpose of this dissertation is to establish the kinetics and mechanism of interfacial creep and to evaluate its impact on thin film structures used in microelectronic devices. Studies of interfacial creep kinetics were based on diffusion-bonded interfaces in Si-Al-Si sandwich specimens, which were loaded in a double-shear configuration with the interfaces being subjected to a nominal shear stress during creep tests. In some tests, a normal stress was superimposed on the applied shear stress to articulate the role of the normal stresses, which are often present at interfaces. It was found that in agreement with previous results, the interface crept by interfacial diffusion-controlled diffusional creep driven by the applied shear stress, with the applied normal compressive stress resulting in a threshold behavior below which no creep occurred. The effect of interfacial roughness was also evaluated and the results showed that the interfacial creep rate decreased for specimens with larger interfacial roughness. The impact of interfacial creep in interconnect structures in microelectronic devices were observed via atomic force microscopy for (a) stand-alone thin film Cu lines on Si and (b) Cu lines embedded in a low k dielectric on Si substrates. Following thermal cycling, changes were observed in the in-plane Cu line dimensions, as well as the out-of plane step height between Cu and dielectric in single layer structures. Both effects were attributed to interfacial diffusion-controlled interface sliding.

KEYWORDS: Interface Sliding, Interfacial Creep, Al-Si Interface, Activation Energy, Amorphous, Diffusion Bonding, Interconnect Structures